DECLARATION

I, Nobuo Arakawa, c/o Fukami Patent Office, Nakanoshima Central Tower, 22nd Floor, 2-7, Nakanoshima 2-chome, Kita-ku, Osaka-shi, Osaka, Japan, declare:

that I know well both the Japanese and English languages;

that to the best of my knowledge and belief the English translation attached hereto is a true and correct translation of Japanese Patent Application No. 2003-431013, filed on December 25, 2003;

that all statements made of my own knowledge are true;

that all statements made on information and belief are believed to be true; and

that the statements are made with the knowledge that willful false statements and the like are punishable by fine or imprisonment, or both, under 18 USC 1001.

Dated: October 3, 2008

N. Arakawa

Nobuo Arakawa

日本国特許庁
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出願人
Applicant(s): シャープ株式会社

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[Inventor]	
[Address]	c/o Sharp Kabushiki Kaisha 22-22, Nagaike-cho, Abeno-ku, Osaka-shi, Osaka
[Name]	Naru USUKURA
[Applicant]	
[Identification Number]	000005049
[Name]	Sharp Kabushiki Kaisha
[Attorney]	
[Identification Number]	100077931
[Patent Attorney]	
[Name]	Hiroshi MAEDA
[Appointed Attorney]	
[Identification Number]	100094134
[Patent Attorney]	
[Name]	Hiroki KOYAMA
[Appointed Attorney]	
[Identification Number]	100113262
[Patent Attorney]	
[Name]	Yuji TAKEUCHI
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[Document]	Scope of Claims for Patent 1
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[Document]	Abstract 1
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[Document Name] Scope of Claims for Patent

[Claim 1]

A substrate with a spacer comprising a substrate; and a spacer formed on said substrate, wherein

said spacer has at least a first spacer portion, and a second spacer portion formed above said first spacer portion, and an upper portion of said first spacer portion has a larger diameter than a bottom of said second spacer portion.

[Claim 2]

The substrate with the spacer according to claim 1, wherein

the upper portion of said first spacer portion has a groove surrounding said second spacer portion in a plan view.

[Claim 3]

The substrate with the spacer according to claim 1 or 2, wherein

assuming that an upper portion of said spacer has a diameter of C, and said spacer has a height of H from the bottom to the upper portion, said spacer has a diameter of (1.8 x C) or more at the bottom, and has a diameter of (1.05 x C) or less at a height of (0.85 x H) from the bottom of said spacer.

[Claim 4]

A panel having the substrate with the spacer according to one of the claims 1 to 3; an opposed substrate opposed to said substrate with the spacer; and a function material layer interposed between said substrate with the spacer and said opposed substrate.

[Claim 5]

The panel according to claim 4, wherein

said function material layer is a liquid crystal layer.

[Claim 6]

A method of manufacturing a panel according to claim 5, comprising the steps of:

forming a frame-like seal member on a substrate surface of one of said substrate with the spacer and said opposed substrate;

applying a liquid crystal material to an inside of a frame of said seal member; and

adhering said substrate with the spacer and said opposed substrate together to form said liquid crystal layer.

[Document Name] Specification

[Title of the Invention]

Substrate with a Spacer

[Technical Field]

[0001]

The present invention relates to a substrate provided with a spacer arranged on the substrate. The substrate with the spacer according to the invention is adhered to a substrate opposed thereto, and thereby a constant space can be kept between these substrates.

[Background Art]

[0002]

In the conventional liquid crystal panel, spherical spacers such as plastic beads are dispersed on one of the substrates before adhering the substrates together for keeping a constant thickness of a liquid crystal layer between a TFT (Thin Film Transistor) substrate and a color filter substrate. However, this manner suffers from a problem of occurrence of irregular display due to irregular dispersion or movement of the beads.

[0003]

For overcoming the above problem, a technique of forming column-structure spacers on a substrate has been developed. The column-structure spacers are formed by applying photosensitive resin onto the substrate and patterning the photosensitive resin by a photolithography method. The column-structure spacers can be formed at desired positions on the substrate surface, and do not move on the substrate surface so that irregular display does not occur. Further, the height thereof can be freely determined depending on manufacturing conditions. However, the liquid crystal material thermally extends in a high-temperature state so that the column-structure spacers cause irregular display due to nonuniformity in cell gap on the surface.

[0004]

Patent reference 1 has disclosed that the irregular display due to changes in temperature can be prevented by storing an elastic energy in the columnar spacers. Each of Patent references has disclosed a structure in which two or more kinds of spacers having different heights or sectional areas are used for preventing the irregular display even when the liquid crystal material shrinks in a low temperature environment or an excessive load is applied thereto. Patent reference 4 has disclosed a structure in which each columnar spacer has a concave or flat top portion for preventing a display failure due to local irregularities in cell thickness.

[0005]

However, the spacers disclosed in the patent references 1 - have a high aspect ratio, and therefore are less resistant to elastic deformation so that the spacers may be damaged in a step of rubbing an alignment film, and may not function as the spacers.

[0006]

In the method (which will be referred to as a "liquid crystal drop adhering method" hereinafter) of performing adhesion after putting drops of the liquid crystal material on the substrate surface, the thickness (cell gap) of the liquid crystal layer depends on the drop quantity of the liquid crystal material. Therefore, when an imbalance occurs between the height of resin spacer and the drop quantity of liquid crystal, an error occurs in display. More specifically, when a large drop quantity of liquid crystal is used, excessive liquid crystal causes irregular display. When the quantity is small, vacuum bubbles occur to cause a significant disadvantage. These vacuum bubbles often occur particularly during an operation of adhering the substrates or at a low temperature, and early overcoming of this problem has been desired.

[0007]

For overcoming the problem, Patent reference 5 has disclosed a method in which a column height of a columnar spacer is measured, and a drop quantity of liquid crystal is controlled based on the measured value. However, when consideration is given to measurement errors, accuracy in control of drop quantity and changes in temperature,

the method disclosed in the Patent reference 5 is not sufficient for the above purpose.

[Patent reference 1] Japanese Patent Laying-Open No. 2001-147437

[Patent reference 2] Japanese Patent Laying-Open No. 2003-121857

[Patent reference 3] Japanese Patent Laying-Open No. 2003-131238

[Patent reference 4] Japanese Patent Laying-Open No. 2002-229040

[Patent reference 5] Japanese Patent Laying-Open No. 2001-147437

[Disclosure of the Invention]

[Problems to be Solved by the Invention]

[0008]

An object of the invention is to reduce display irregularities due to irregularities in cell gap on a surface. Another object of the invention is to suppress effectively damages on spacers due to rubbing processing. Still another object of the invention is to reduce the display irregularities due to changes in temperature and an excessively large or small drop quantity of liquid crystal.

[Means for Solving the Problems]

[0009]

A substrate with a spacer of the invention includes a substrate and a spacer formed on the substrate, and the spacer has at least a first spacer portion and a second spacer portion formed above the first spacer portion. An upper portion of the first spacer portion has a larger diameter than a bottom of the second spacer portion.

[0010]

Preferably, the upper portion of the first spacer portion preferably has a groove surrounding the second spacer portion in a plan view.

[0011]

Preferably, assuming that an upper portion of the spacer has a diameter of C, and the spacer has a height of H from the bottom to the upper portion, it is preferable that the spacer has a diameter of (1.8 x C) or more at the bottom, and has a diameter of (1.05 x C) or less at a height of (0.85 x H) from the bottom of the spacer.

[0012]

A panel of the invention has the substrate with the spacer of the invention, an opposed substrate opposed to the substrate with the spacer, and a function material layer interposed between the substrate with the spacer and the opposed substrate. The function material layer includes a layer having a light transmittance modulated by a potential difference between electrodes opposed to each other, and a layer emitting light by itself according to a current flowing between the opposed electrodes. For example, the function material layer is a liquid crystal layer, inorganic or organic electroluminescence (EL) panel, light emission gas layer, electroluminescence layer or the like. Therefore, the panels of the invention include a liquid crystal panel as well as inorganic and organic panels.

[0013]

A method of the invention is a method of manufacturing a liquid crystal display panel in a liquid crystal drop adhering manner. The method of the invention includes the steps of forming a frame-like seal member on a substrate surface of one of a substrate with a spacer and an opposed substrate; applying a liquid crystal material to an inside of a frame of the seal member; and adhering the substrate with the spacer and the opposed substrate together to form a liquid crystal layer.

[Effects of the Invention]

[0014]

According to an aspect of the invention, uniform cell gaps can be obtained on the surface. According to another aspect of the invention, damages on the spacers due to rubbing processing can be effectively suppressed. Still another aspect of the invention, it is possible to reduce display irregularities due to changes in temperature and an excessively large or small drop quantity of liquid crystal.

[Best Modes for Carrying Out the Invention]

[0015]

Embodiments of the invention will be described below with reference to the

drawings. The following embodiments will be described in connection with a substrate with spacers for use in a liquid crystal panel. The substrate with spacers according to the invention can be used not only in the liquid crystal panel but also in an organic EL panel, inorganic EL panel, plasma panel, field emission panel, electrochromic panel and others. The liquid crystal panel can be applied not only to the liquid crystal display panel but also to a picture shift panel that optically and successively shifts pixels as well as a parallax barrier panel that allows display of three-dimensional pictures. The picture shift panel includes at least one set of the liquid crystal panel modulating a polarization state of light and birefringent elements combined with the liquid crystal panel for shifting a light path according to the polarization state of light coming from the liquid crystal panel. The parallax barrier panel is combined with picture display elements having pixels for the left eye and pixels for the right eye, and thereby can display three-dimensional pictures.

[0016]

(First Embodiment)

Fig. 1 is a cross section schematically showing a liquid crystal panel using a substrate with a spacer of a first embodiment. The liquid crystal panel has a pair of substrates 1 and 2, a peripheral seal member 3 held between substrates 1 and 2, a liquid crystal layer 4 located between substrates 1 and 2 and surrounded by peripheral seal member 3, and a spacer 5 for keeping a uniform cell gap of liquid crystal layer 4. Substrate 1 is a color filter substrate, and has a color filter layer (not shown), transparent electrodes made of ITO (Indium Tin Oxide) and a liquid crystal alignment film (not shown) made of polyimide and the like and subjected to rubbing processing. The other substrate 2 is a TFT (Thin Film Transistor) substrate, and has a plurality of gate bus lines (not shown) each extending in a row direction, a plurality of source bus lines (not shown) crossing the gate bus lines, TFTs (not shown) arranged near crossings of the gate and source bus lines, pixel transparent electrodes (not shown) arranged in a matrix form and connected to the source bus lines (not shown) via the TFTs and a liquid crystal

alignment film (not shown) covering the pixel transparent electrodes.

[0017]

Substrates 1 and 2 may be made of glass such as silica glass, soda lime glass, borosilicate glass, low alkali glass or non-alkali glass, plastics such as polyester or polyimide, or semiconductor such as silicon.

[0018]

Fig. 2 is a cross section schematically showing, on an enlarged scale, spacer 5 of the embodiment. Fig. 3 is a plan of spacer 5. This embodiment will now be described in connection with a structure having spacers 5 formed on color filter substrate 1, but spacers 5 may be formed on TFT substrate 2.

[0019]

Spacer 5 has a first spacer portion 5a and a second spacer portion 5b formed above first spacer portion 5a. Each of first and second spacer portions 5a and 5b has a truncated conical form, and an upper portion of first spacer portion 5a has a diameter A larger than a diameter B of a bottom portion of second spacer portion 5b.

[0020]

As shown in Figs. 2 and 3, spacer 5 has a form of a combination of first spacer portion 5a having a relatively large top area (i.e., area of a top surface) and second spacer portion 5b having a relatively small top surface. By employing this combination form, damages due to rubbing processing can be effectively suppressed in spite of the fact that a portion (second spacer portion 5b) having a relatively small top area is located at a high position spaced from the surface of substrate 1.

[0021]

Since second spacer portion 5b having the relatively small top area is formed above first spacer portion 5a having the relatively large top area (area of the top surface), load-displacement characteristics of the spacer can change stepwise. Fig. 4 is a graph illustrating the load-displacement characteristics of spacer 5 of this embodiment. As illustrated in Fig. 4, the load-displacement characteristics in the graph represent a steep

curve before the displacement exceeds a height h2 of second spacer portion 5b, and the load-displacement characteristics significantly change to represent a relatively gentle curve according to increase in load after the displacement exceeds height h2 of second spacer portion 5b. More specifically, when the load is applied after the displacement exceeds height h2 of second spacer portion 5b, further displacement is substantially suppressed. Thereby, second spacer portion 5b can elastically deform to follow the load caused by an error in liquid crystal drop quantity and changes in temperature. When a large pressure is locally applied, the stress of first spacer portion 5a substantially suppresses deformation of the panel.

[0022]

For a comparison with this embodiment, an example for the comparison will now be described. Fig. 5 is a cross section schematically showing a spacer 50 of the example for comparison. Spacer 50 has a single truncated conical form as shown in Fig. 5. Since the spacer is generally formed by the photolithography method, a diameter C of an upper portion of spacer 50 depends on an accuracy of an exposing device and the like. When a general exposing device of a proximity type is used, upper diameter C of spacer 50 is in a range from about 6 to about 10 μm, and the bottom diameter of spacer 50 is about (1.5 x C) μm. Therefore, an aspect ratio of spacer 50 is about (H/(1.5 x C)) where H (μm) is a height of spacer 50. By using the exposing device of, e.g., a stepper type or a mirror projection type having a high accuracy, it is possible to produce spacers of further reduced sizes. However, spacers having excessively small sizes may break in rubbing processing.

[0023]

Fig. 6 is a cross section for illustrating sizes of spacer 5 of the embodiment. Spacer 5 of the embodiment has a structure corresponding to a vertical combination of first and second spacer portions 5a and 5b each having a truncated conical form. Since upper diameter A of first spacer portion 5a is larger than bottom diameter B of second spacer portion 5b, a bottom diameter D of spacer 5 can be longer than that of spacer 50

of the comparison example. For example, bottom diameter D of spacer 5 can be (1.8 x C) or more. Therefore, the aspect ratio of spacer 5 can be equal to or smaller than (H/(1.8 x C)), and thus can be smaller than that of spacer 50 of the comparison example so that breakage in the rubbing processing can be prevented even when the spacers have small sizes.

[0024]

Typical sizes of spacer 5 will now be described. Since it is economically advantageous to use the exposing device of the proximity type, the following description is given on the case where the exposing device of the proximity type is used. Since the accuracy limit of the exposing device of the proximity type is about 6 μm, the possible minimum value of upper diameter C of second spacer portion 5b is about 6 μm. Also, spacer 5 (i.e., first spacer portion 5a in this embodiment) is configured to have bottom diameter D that is larger by 1.8 times or more than top diameter C of second spacer portion 5b. However, when bottom diameter D of spacer 5 is excessively large, spacer 5 protrudes over a pixel opening, and exerts adverse effect on display, e.g., by lowering the transmittance and reflectance. Accordingly, spacer 5 has bottom diameter D of about 14 μm for preventing protrusion over the pixel opening. When second spacer portion 5b has upper diameter C of 6 μm, it is preferable that the spacer density in the cell is about 1100 pcs/cm^2.

[0025]

Height H of spacer 5 is substantially equal to the cell gap of liquid crystal layer 4. More specifically, it is about 5 μm in the transparent type, and is about 2.5 μm in the reflection display type. However, spacers 5 slightly collapse when substrates 1 and 2 are overlaid, and therefore height H of spacer 5 becomes equal to a value obtained by adding a prospected value (about 0.2 μm) of such collapse to the cell gap. For example, it is about 5.2 μm in the transparent type, and is 2.7 μm in the reflection display type.

[0026]

Second spacer portion 5b elastically deforms according to the load caused by an error of the liquid crystal drop quantity and changes in temperature. Height h2 of second spacer portion 5b is set to a value that prevents spacer 5 from collapsing by a predetermined thickness or more even when it locally receives a large stress. Height h2 is determined in view of the liquid crystal drop quantity, variations in height of spacers 5, shifting of cell gaps on the surface due to expansion of the liquid crystal material and others. Height h2 of second spacer portion 5b is preferably in a range from 0.4 μm to 0.7 μm, and is typically equal to 0.5 μm.

[0027]

In spacer 5 of the embodiment having height H from the bottom to the top, a diameter E of spacer 5 at a height of (0.85 x H) from the bottom is equal to or smaller than (1.05 x C), i.e., 1.05 times of diameter C of the top of spacer 5.

[0028]

Description will now be given on steps of manufacturing the liquid crystal display panel using the substrates with the spacer of the embodiment. First, the color filter layer and the transparent electrodes are successively formed on substrate 1 by the sputter method and print method. Acrylic resin resist of an ultraviolet curing type is applied onto substrate 1 and is dried, and then spacers 5 are formed at light interception positions between pixels by the photolithography method. The photolithography method uses a gradation photomask having a light intercepting portion for partially changing the light transmittance continuously or stepwise (e.g., Patent reference No. 4). After the exposure using the gradation photomask, development is performed to form spacers 5 having different heights (i.e., exhibiting a stepped portion). Further, polyimide which is an alignment film material is applied to substrate 1, and the rubbing processing is effected to form the alignment film.

[0029]

Various kinds of bus lines, insulating films, TFTs and pixel transparent electrodes are formed on the other substrate 2 by the photolithography method and the

print method, and thereafter the alignment film subjected to the rubbing processing is formed to cover the pixel transparent electrodes. Peripheral seal member 3 of the ultraviolet curing type containing epoxy resin is formed on one of substrates 1 and 2 by the screen-print method and the dispenser method. Peripheral seal member 3 has a pattern of a loop form, and does not have an opening providing a liquid crystal inlet. After applying drops, e.g., of nematic liquid crystal material to a region inside the pattern frame of peripheral seal member 3, two substrates 1 and 2 are overlaid with each other in the vacuum chamber to form liquid crystal layer 4 in the gap between substrates 1 and 2.

[0030]

The distance between substrates 1 and 2, i.e., the thickness (cell gap) of liquid crystal layer 4 depends on the quantity of the applied liquid crystal material drops and the height of peripheral seal member 3. However, irregularities in the cell gap are liable to occur on the surface if the cell gap is determined only by the liquid crystal material and peripheral seal member 3. Since a member defining the cell gap is not present in a region other than the peripheral portion of the panel, the panel is significantly affected by an external pressure to cause display irregularities. In this embodiment, spacers 5 defining the cell gap are arranged to keep the cell gap substantially uniform in the display region on substrate 1. Therefore, the external pressure hardly affects the panel so that the display irregularities hardly occur.

[0031]

In this embodiment, since second spacer portion 5b on first spacer portion 5a absorbs the load caused by the error in liquid crystal drop quantity and the changes in temperature, it is possible to suppress the display irregularities due to nonuniformity in cell gap on the surface. Since first spacer portion 5a has upper diameter A longer than bottom diameter B of second spacer portion 5b, the stress of first spacer portion 5a can function to keep the display quality by suppressing deformation which may be cause by a local large stress occurring at the time of adhering the substrates.

[0032]

After overlaying substrates 1 and 2 with each other, ultraviolet light is applied for provisionally curing a portion of the seal member (which may also be referred to as a "dummy seal member") at the position other than peripheral seal member 3. The panel is taken out from the vacuum chamber, and peripheral seal member 3 is irradiated with the ultraviolet light to cure peripheral seal member 3. Through the above steps, the liquid crystal panel shown in Fig. 1 is completed.

[0033]

Although the liquid crystal panel of this embodiment uses the TFTs as the liquid crystal drive elements, another type of active drive elements such as MIM (Metal Insulator Metal) may be used, or passive (multiplex) drive not using the drive element may be employed. When using the liquid crystal panel as the display panel, it can be applied to the display panel of any one of the transparent type, reflection type and transparent-reflection dual type.

[0034]

This embodiment has been described in connection with the method of manufacturing the liquid crystal panel by the liquid crystal drop adhesion method. However, another type of liquid crystal panel may be produced using the substrates with the spacer according to the invention.

[0035]

(Second Embodiment)

Fig. 7 is a cross section schematically showing the substrate with the spacer according to a fourth embodiment of the invention, and Fig. 8 is a plan thereof. Spacer 5 of this embodiment is substantially the same as spacer 5 of the first embodiment except for that first spacer portion 5a has a groove 5c at its upper portion. Therefore, the forms, sizes and manufacturing method of spacers 5 of this embodiment are substantially the same as those of the first embodiment, and description thereof is not repeated.

[0036]

Groove 5c formed near the bottom of second spacer portion 5b surrounds second spacer portion 5b in a plan view. Although groove 5c in this embodiment has a continuously annular form, it may be discontinuous. Groove 5c has a V-shaped sectional form in Fig. 7, but may have another form such as a U-shaped form. Although a width F of groove 5c is not particularly restricted, it is preferably in a range from 0.2 μm to 2 μm. Likewise, a depth G of groove 5c is not particularly restricted, but is preferably in a range from 0.2 μm to 1 μm.

[0037]

In a plan view, groove 5c surrounds second spacer portion 5b so that second spacer portion 5b can readily and elastically deform according to the load caused by the error in liquid crystal drop quantity and the changes in temperature, and the load can be absorbed more reliably.

[0038]

(Third and Fourth Embodiments)

In the first and second embodiments, each of first and second spacer portions 5a and 5b has the truncated conical form, but the forms of first and second spacer portions 5a and 5b are not restricted to it. (a) and (b) of Fig. 9 schematically show spacers of third and fourth embodiments, respectively, and each include a plan (upper portion) and a cross section (lower portion).

[0039]

As shown in Fig. 9(a), each of first and second spacer portions 5a and 5b has a circular cylindrical form, and second spacer portion 5b may be formed substantially at a center of the top portion of first spacer portion 5a. Alternatively, as shown in Fig. 9(b), second spacer portion 5b may be formed at a periphery of the top portion of first spacer portion 5a. Spacer 5 shown in each of (a) and (b) of Fig. 9 can substantially achieve effects similar to those of spacers 5 of the first and second embodiment.

[0040]

(Other Embodiments)

First and second spacer portions 5a and 5b in the first and second embodiments have the truncated conical forms, and those in the third embodiment have the circular cylindrical form. In other words, each of spacer portions 5a and 5b in the first to third embodiments has the circular top and circular bottom surface. However, the forms of the top and bottom surfaces of spacer portions 5a and 5b are not particularly restricted, and for example, these may be polygonal or elliptic. Each of the top surfaces of spacer portions 5a and 5b may not be parallel to the substrate surface, and may be inclined with respect to the substrate surface. When a sectional surface, which is parallel to the substrate surface, of the top or bottom portion of spacer portion 5a or 5b is not circular, the longest line segment among straight line segments crossing the sectional surface is referred to as the "diameter".

[0041]

The first to fourth embodiments have been described in connection with the structures that include spacers 5 each formed of two spacer portions 5a and 5b. However, the spacer may have a multi-step structure formed of more than two spacer portions.

[Industrial Applicability]

[0042]

The substrate with spacers according to the invention can be used in the organic EL panel, inorganic EL panel, plasma panel, field emission panel, electrochromic panel and others.

[Brief Description of the Drawings]

[0043]

[Fig. 1] is a cross section schematically illustrating a liquid crystal panel using a substrate with spacers of a first embodiment.

[Fig. 2] is a cross section schematically showing on an enlarged scale a spacer 5 of the first embodiment.

[Fig. 3] is a plan of spacer 5 of the first embodiment.

[Fig. 4] is a graph illustrating load-displacement characteristics of spacer 5 of the first embodiment.

[Fig. 5] is a cross section schematically showing a spacer 50, which is an example for comparison.

[Fig. 6] is a cross section for illustrating sizes of spacer 5 of the first embodiment.

[Fig. 7] is a cross section schematically showing a substrate with spacers of a second embodiment.

[Fig. 8] is a plan of the substrate with spacers of the second embodiment.

[Figs. 9] Fig. 9(a) and (b) are a plan (upper) and a cross section (lower) schematically showing a spacer of third and fourth embodiments.

[Description of the Reference Signs]

1, 2 substrate

3 peripheral seal member

4 liquid crystal layer

5 spacer

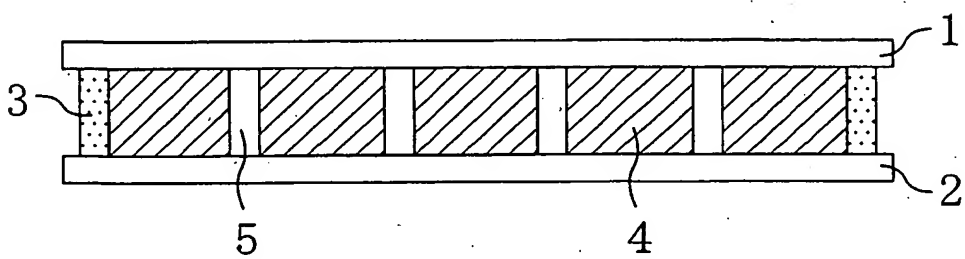
5a first spacer portion

5b second spacer portion

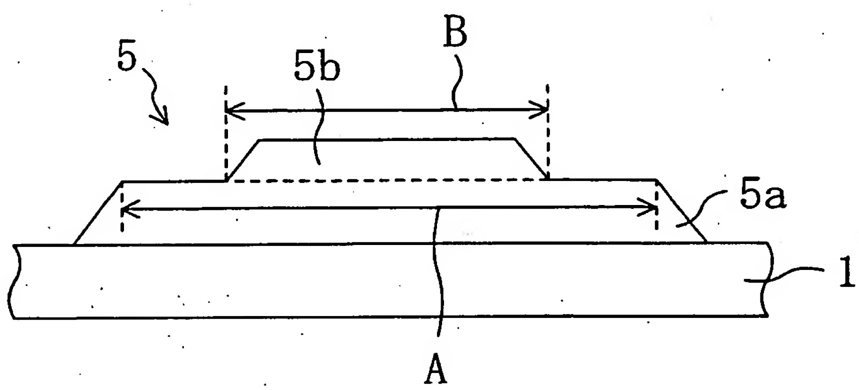
5c groove

50 spacer

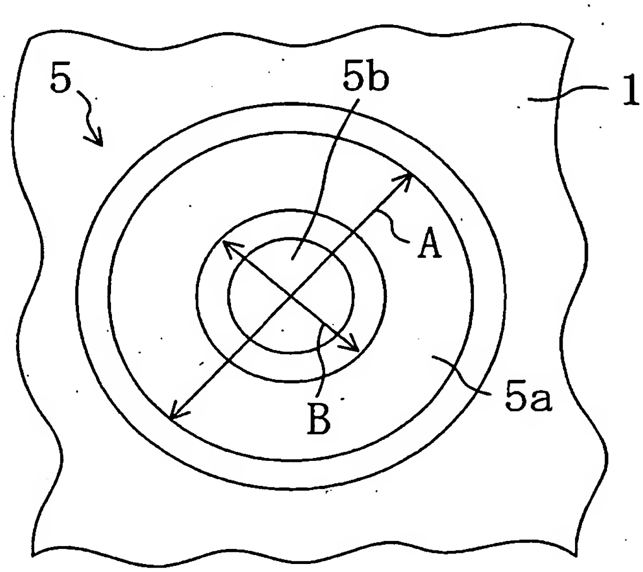
【書類名】図面 [name of the document] drawing
【図１】Fig. 1



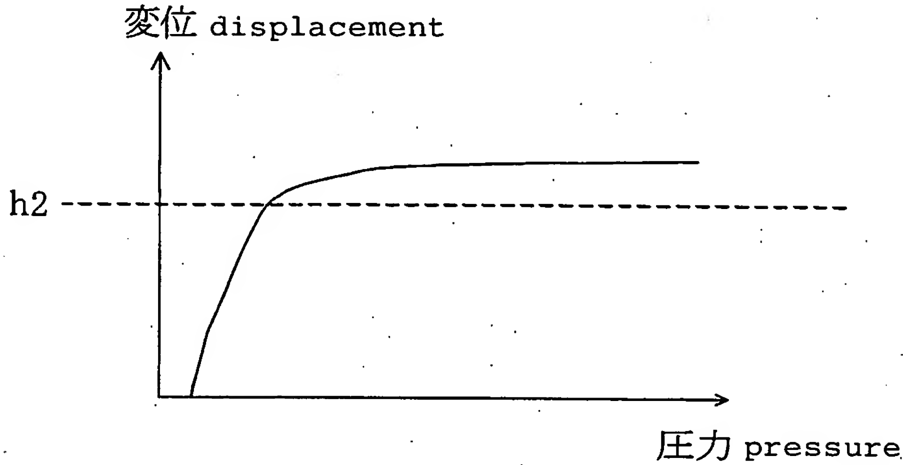
【図２】Fig. 2



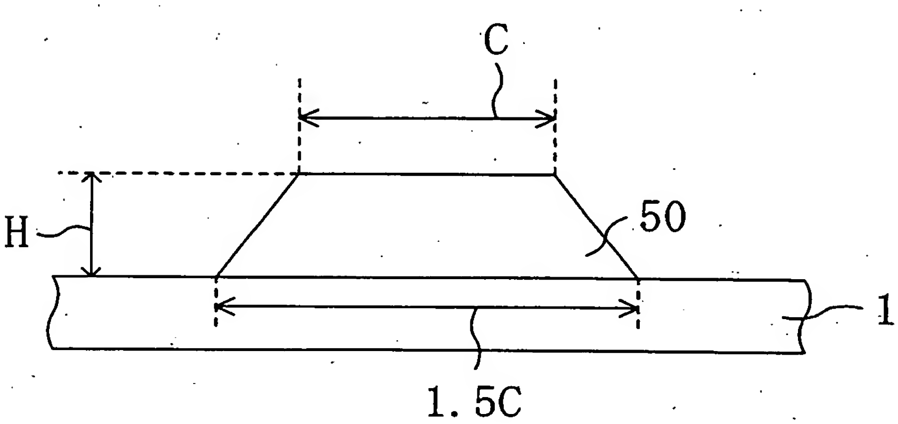
【図３】Fig. 3



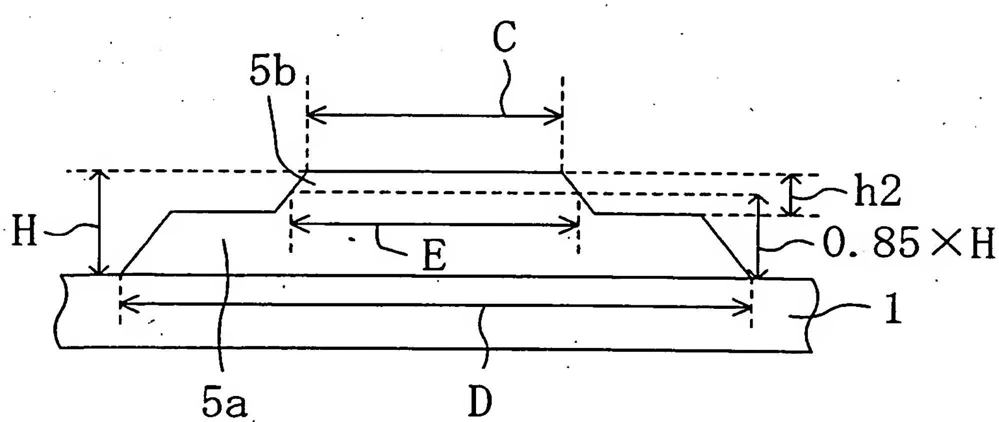
【図4】Fig. 4



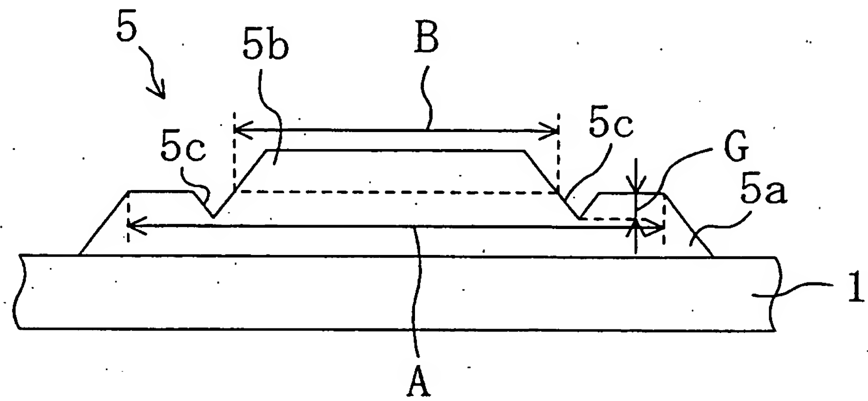
【図5】Fig. 5



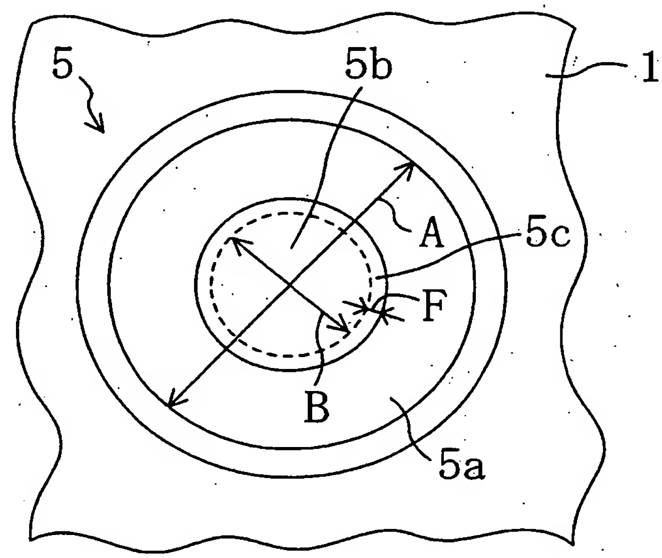
【図6】Fig. 6



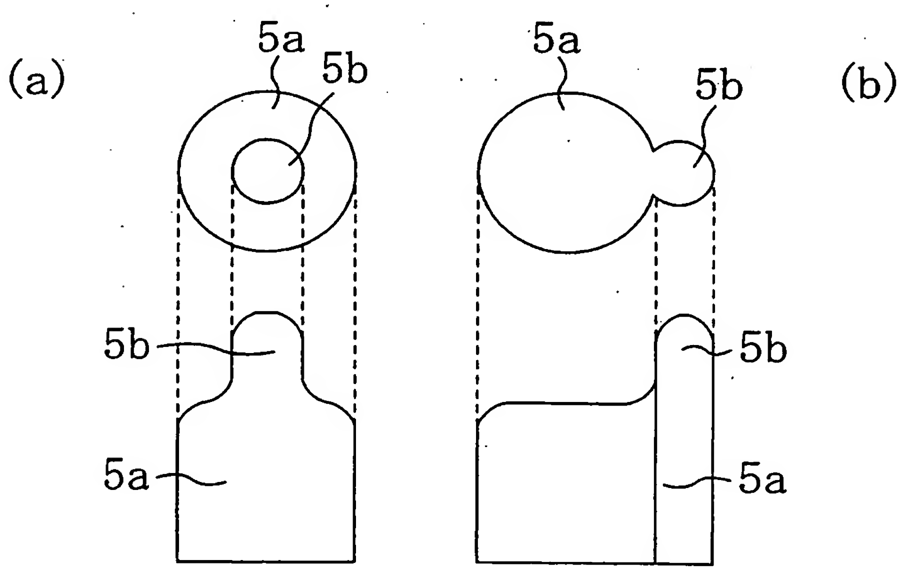
【図７】Fig. 7



【図８】Fig. 8



【図９】Fig. 9



[Document Name] Abstract

[Abstract]

[Subject] An object is to reduce display irregularities due to irregularities in cell gap on a surface, to suppress effectively damages on spacers due to rubbing processing and to reduce the display irregularities due to changes in temperature and an excessively large or small drop quantity of liquid crystal.

[Solving Means] A substrate with a spacer includes a substrate 1 and a spacer 5 formed on the substrate 1. The spacer 5 has at least a first spacer portion 5a and a second spacer portion 5b formed above the first spacer portion 5a. An upper portion of the first spacer portion 5a has a diameter A larger than a diameter R of a bottom of the second spacer portion 5b.

[Selected Drawing] Fig. 2